# Unexpected interactions between gold and N-morpholino-sulfonates

**Nielsen, Frederick Stappen; Engelbrekt, Christian; Elliot, Samuel Gilbert; Junor, Glen; Sørensen, Kasper; Jensen, Knud J.; Clausen, Mads Hartvig; Zhang, Jingdong**

*Publication date:*
2017

*Document Version*
Peer reviewed version

**Unexpected interactions between gold and N-morpholino-sulfonates**

Frederick Stappen[1], Christian Engelbrekt[1], Samuel Eliot[1], Glen Junor[2], Kasper Sørensen[3], Knud J. Jensen[3], Mads H. Clausen[1]and Jingdong Zhang[1].

*[1]Department of Chemistry, Technical University of Denmark, [2]Department of Chemistry, University of California San Diego, [3]Department of Chemistry, University of Copenhagen. fcksn@kemi.dtu.dk*

Nanoporous gold (NPG) has a high surface area and excellent conductivity. It is an ideal supporting material for the electrocatalysis, e.g. in fuel cell applications. NPG is traditionally produced by etching a gold/silver alloy. This method has significant drawbacks, such as the introduction of silver into your NPG, and its multi-step fabrication. A method has been discovered for producing NPG as a thin film chemically. This bottom-up approach entails reduction of $Au^{3+}$ precursor using morpholinoethanesulfonic acid (MES). This produces a thin and highly porous gold film at the air-water interface[1] (*for details, see poster by Mikkel Christiansen)*.

This chemical reaction is far more complex than first expected and bi-products, intermediates and reaction mechanisms are the focus of the present work.

The chemical reaction and its products have been examined using state-of-the-art nuclear magnetic resonance (NMR), ultraviolet-visible spectroscopy (UV-vis), fluorescence spectroscopy, density functional theory (DFT), mass spectrometry (MS) and Raman spectroscopy. The results illustrate a complex chain of reactions resulting in gold nanoparticles, NPG, and several previously unidentified Au-complexes. N-NMR presented three different environments for the N-atom in MES, while the UV-vis results points towards some interesting gold complexes. MS identifies several distinct molecular entities demonstrating the reactivity of MES and Au, and fluorescence spectroscopy suggests the formation of polynuclear Au complexes as previously reported where Au nuclei are bridged by C=N functionalities in small organic molecules[2]. This adds up to a complicated reaction mechanism involving some interesting $Au^{3+/1+}$ complexes, deprotonation and oxidation of MES and the formation of molecules that show UV-vis absorbance and fluorescencet.

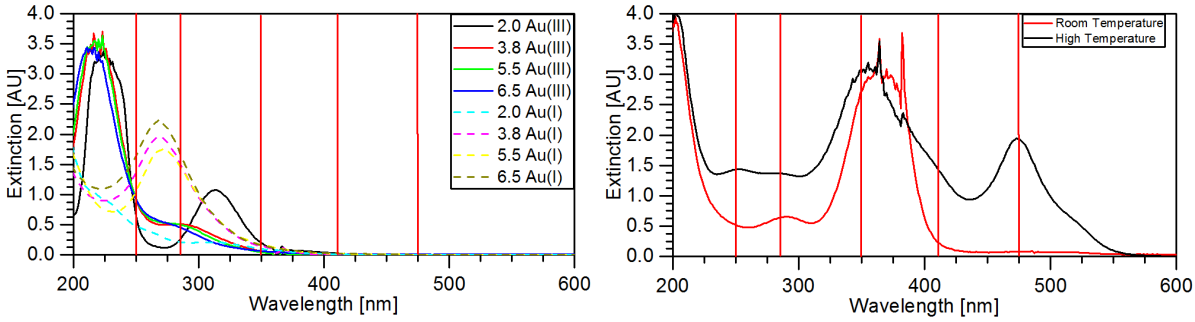


Figure 1 – (left), UV-vis spectra of $AuCl_x(H_2O)_y$ complexes corresponding to (right) those found after the reaction between gold and MES.

(1) Engelbrekt, C.; Wagner, M.; Christiansen, M. U.-B.; Christensen, H. E. M.; Qian, X.; Ulstrup, J.; Zhao, C.; Zhang, J. Side Effect of Good's Buffers on Optical Properties of Gold Nanoparticle Solutions. *ChemElectroChem* **2016**, 2015–2016.

(2) Fung, E. Y.; Olmstead, M. M.; Vickery, J. C.; Balch, A. L. Glowing Gold Rings: Solvoluminescence from Planar trigold(I) Complexes. *Coord. Chem. Rev.* **1998**, *171*, 151–159.